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EVALUATION OF DISPOSAL AREAS IN JAMES RIVER: HYDRAULIC MODEL IN--ETC(U)
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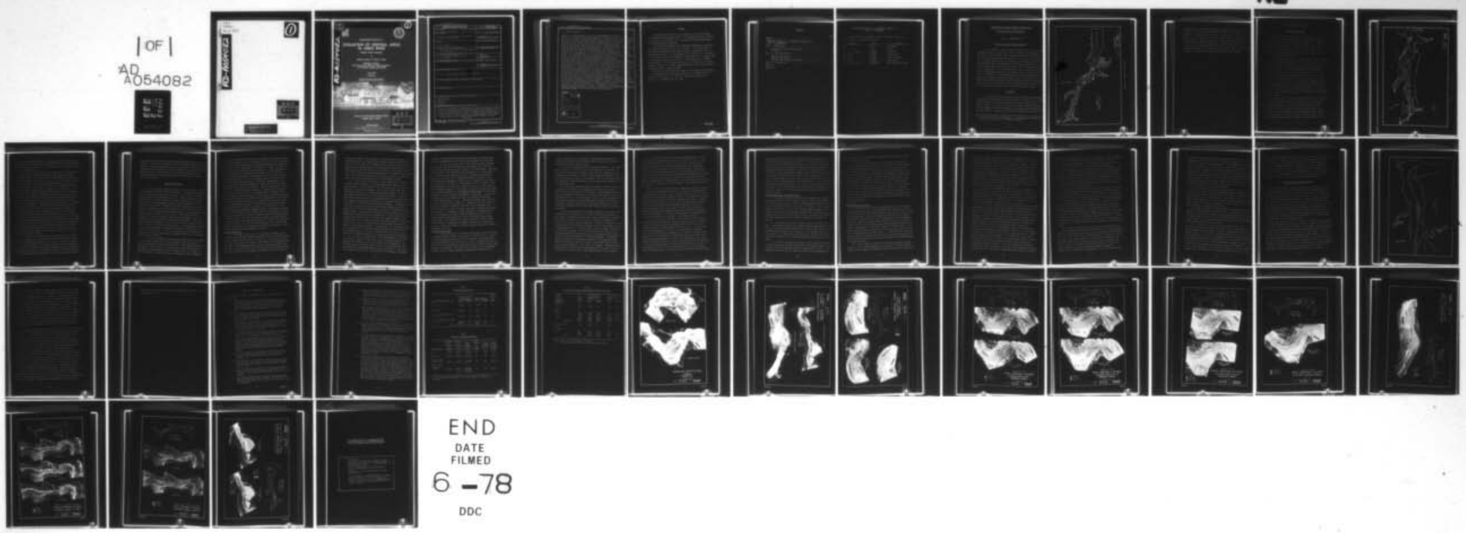

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EVALUATION OF DISPOSAL AREAS IN JAMES RIVER

Hydraulic Model Investigation

by

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The existing comprehensive fixed-bed model of James River was used to study the major disposal areas used during maintenance dredging operations for the existing 25-ft-deep navigation channel to determine if the disposal areas are performing satisfactorily in terms of retaining dredged material placed therein. If the test results indicated a probable excessive rate of return of dredged material to the channel, the tests were expanded to include
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20. ABSTRACT (Continued).

studies of an alternate area or areas in the same general vicinity to determine if a more suitable disposal area could be defined. The tests consisted of the release of lightweight sediments at surface depth in the disposal areas, tracing patterns of movement of material from the areas, and defining areas where these sediments would probably deposit. The results indicated that, in general, the disposal areas and operating procedures presently employed are satisfactory with respect to areas of material deposition and material retention characteristics. Maintenance requirements for the Skiffes Creek channel would probably be reduced if use of the downstream 4000 ft of the Tribell shoal disposal area is shifted to the opposite side of the channel. A significant portion of the material discharged in the downstream 8450 ft of the Goose Hill shoal disposal area returns to the navigation channel, and shifting that portion of the disposal area to the north side of the channel should improve this condition. Releasing material in the Jordan Point-Windmill Point disposal area 2 results in rapid filling in Herring Creek which is probably objectionable. The sediment trap suggested for the Jordan Point-Windmill Point shoal reach would not function to the extent required and is not recommended. The estimated annual loss of depth in all disposal areas tested, except at the downstream half of Jordan Point-Windmill Point shoal reach, was 0.10 ft or less for the present shoaling rates, indicating an extended period of future use without adverse effects. The estimated annual loss of depth in the downstream Jordan Point-Windmill Point disposal areas 1 to 5 varied between about 0.10 and 0.40 ft, indicating this reach to be the most critical with respect to continuing present channel maintenance practices. Alternate disposal schemes for this reach should be developed. Further tests should be conducted in the model to determine the effects of filling the disposal areas to minimum allowable depths. For example, the disposal areas could be completely filled to some assumed condition that would exist in the future because of continued use. The disposal tests could be repeated for the future filled condition to determine associated changes in hydraulic, salinity, shoaling, and dispersion conditions. Estimates of the environmental impact of all disposal areas could then be made.

PREFACE

The tests reported herein were conducted in the existing James River model and were authorized by U. S. Army Engineer District, Norfolk, in a letter to the Director, U. S. Army Engineer Waterways Experiment Station (WES), dated 13 May 1968.

The study was performed in the Hydraulics Laboratory of WES under the general supervision of Mr. E. P. Fortson, Jr. (retired), Chief of the Hydraulics Laboratory; and under the direct supervision of Mr. H. B. Simmons, present Chief of the Hydraulics Laboratory, Mr. F. A. Herrmann, Jr., Assistant Chief of the Hydraulics Laboratory, Mr. R. A. Sager, Chief of the Estuaries Division, and Mr. W. H. Bobb, Chief of the Interior Channel Branch. The tests were made by Mr. R. A. Boland, Jr., Project Engineer, and Mr. H. R. Smith, Engineering Technician. This report was prepared by Messrs. Boland and Bobb.

Directors of WES during the conduct of the study and the preparation and publication of this report were COL L. A. Brown, CE; BG E. D. Peixotto, CE; and COL G. H. Hilt, CE. Technical Directors were Messrs. J. B. Tiffany and F. R. Brown.

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
inches	2.54	centimeters
feet	0.3048	meters
miles (U. S. statute)	1.609344	kilometers
square yards	0.836127	square meters
square miles	2.58999	square kilometers
cubic yards	0.764555	cubic meters
cubic feet per second	0.02831685	cubic meters per second

EVALUATION OF DISPOSAL AREAS IN JAMES RIVER

Hydraulic Model Investigation

PART I: INTRODUCTION

Purpose and Scope of Investigation

1. For a number of years the Norfolk District has been using the open-water disposal technique to dispose of material dredged during maintenance of the existing James River navigation channel extending fr deep water in Chesapeake Bay some 100 miles* to the city of Richmond, Va. The model study was made to determine if the areas used for dispos between Newport News and Hopewell are performing satisfactorily in term of retaining dredged material placed therein and to obtain some idea of the life expectancy of the respective areas. The tests involved placement of lightweight sediments in the disposal areas in a manner simulative to the discharge of dredged material in the prototype, tracing patterns of material movement from such areas, and defining the areas i which the transported sediments from the disposal areas were deposited. When an area or a portion thereof was found unsatisfactory, alternate locations were tested until a more satisfactory area was found.

The Model

2. The tests were accomplished in the existing James River model, which reproduced the entire James River estuary, a portion of the lower Chesapeake Bay, and about 200 square miles of the Atlantic Ocean as shown in Figure 1. The tidal portions of all major tributary streams were reproduced, including the Appomattox, Chickahominy, Nansemond, and Elizabeth Rivers. The model was about 550 ft long and 130 ft wide at

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

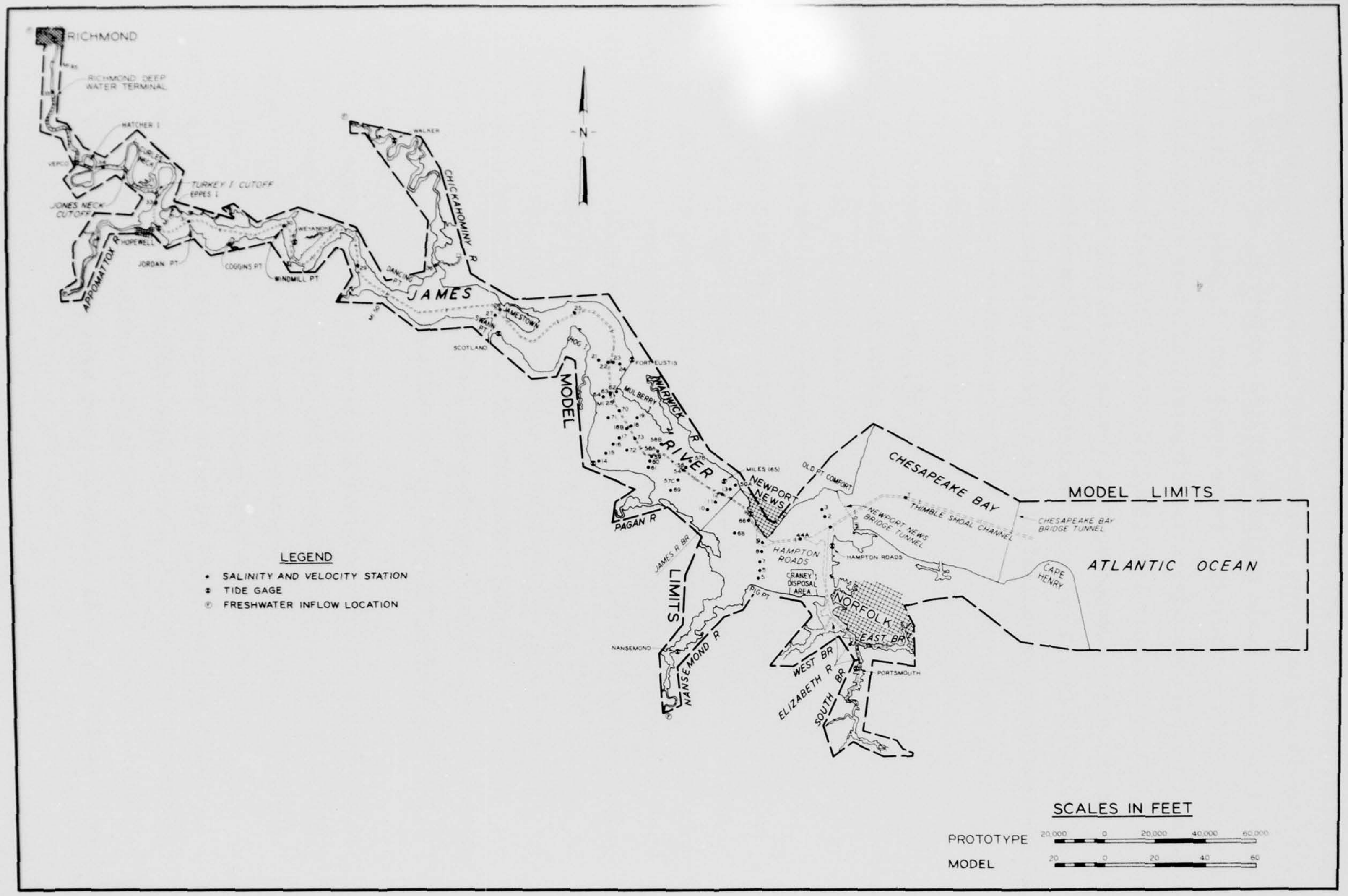


Figure 1. General location map

the widest point, and was located within a shelter to eliminate local wind effects and to permit uninterrupted operation. The model was constructed to linear scale ratios, model to prototype, of 1:1000 horizontally and 1:100 vertically. Other scale ratios, model to prototype, were as follows: salinity 1:1, velocity 1:10, time 1:100, discharge 1:1,000,000, and volume 1:100,000,000. A semidiurnal tidal cycle of 12 hr and 25 min was reproduced in the model in 7.45 min. The model was equipped and adjusted to correctly reproduce tides, tidal currents, and salinities throughout all significant rivers and tidal channels.

PART II: TESTS AND RESULTS

Shoaling Verification

3. Conditions installed in the model throughout the study consisted of the existing 300-ft-wide by 25-ft-deep channel from Newport News to Richmond, along with the proposed enlargement of the Newport News Channel and anchorages. All tests were conducted for a mean tide range of 2.5 ft at Hampton Roads, a constant source salinity adjusted to 24.2 ppt, and mean freshwater inflows as follows: James River at Richmond, 7500 cfs; Appomattox River, 1000 cfs; Chickahominy River, 300 cfs; and Nansemond River, 700 cfs.

4. Adjustment of the model to reproduce prototype tides, currents, and salinities was accomplished prior to conducting the studies reported herein; and no additional adjustment for this purpose was required. Shoaling verification in the problem area had not been accomplished, however; and tests were conducted to demonstrate the ability of the model to reproduce known prototype shoaling characteristics. This was accomplished by first operating the model to salinity stability, then introducing a shoaling material into the model, continuing to operate the model for a sufficient time to allow currents to transport and deposit the material, and subsequently retrieving and measuring the material from designated reaches of the navigation channel. A percentile comparison of corresponding model and prototype quantities was then made to determine if material distribution in the model agreed satisfactorily with the prototype.

5. Gilsonite, with a specific gravity of about 1.040 and graded in size to pass a 24-mesh screen and be retained on a 35-mesh screen, was the material used in the model to simulate prototype sediments. The gilsonite was mixed with water in a tank in the proportions of 7 percent gilsonite and 93 percent water by volume and subsequently distributed to the model through a perforated injection pipe suspended about 18 in. above the center line of the navigation channel. The injection pipe was divided into two sections as shown in Figure 2 for

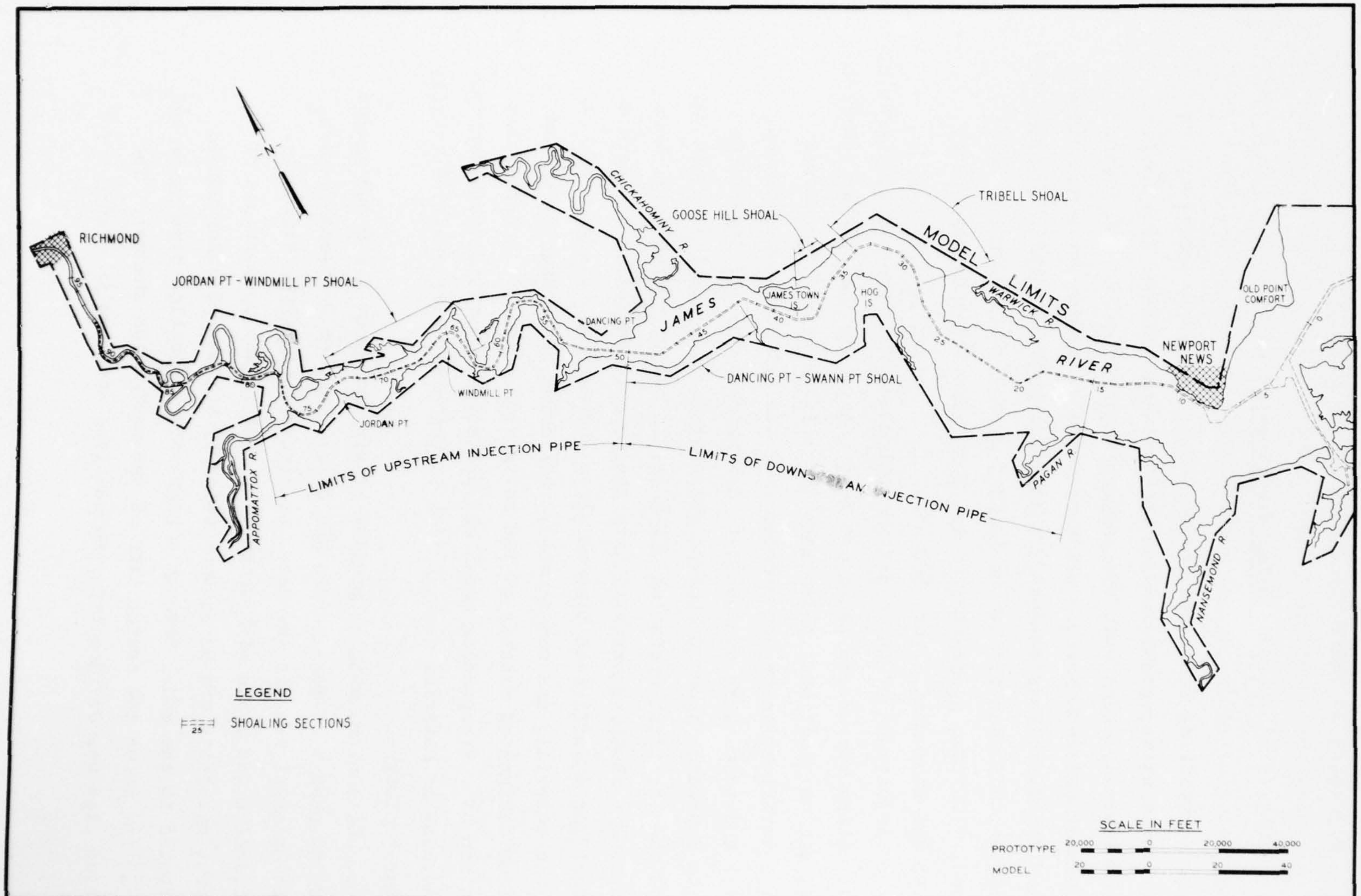


Figure 2. Shoaling verification of 25-foot channel

adjustment and control purposes. The downstream section extended from the upstream end of shoal section 15 (river mile 15) to the upstream end of section 49 (river mile 49). The upstream section extended from river mile 49 to river mile 80.

6. The first tests conducted in the model were for the purpose of verifying prototype channel shoaling in the four major shoal areas (Tribell shoal, Goose Hill shoal, Dancing Point-Swann Point shoal, and Jordan Point-Windmill Point shoal) for existing 25-ft channel conditions. After several trial tests, the following procedures were adopted and followed thereafter. The model was operated for a minimum of 26 tidal cycles to obtain a stable salinity regimen, then about 159,000 cc of gilsonite (in the slurry described above) was injected into the model during selected intervals of maximum current in both the ebb and flood directions. About 70 percent of the material was injected through the downstream injection pipe, and the remaining 30 percent was injected through the upstream pipe. Twelve tidal cycles were required to complete the injection procedure. Half the material was injected during the twelve 3-hour periods centered around the occurrence of maximum flood current, and half the material was injected during the intervening twelve 3-hour periods centered around maximum ebb. After injection of the gilsonite was completed, model operation was continued for 27 tidal cycles to permit movement and deposition of the material by tidal current action. Model operation was then stopped, and the gilsonite deposited in each of the four major shoal areas shown in Figure 2 was retrieved and measured. The percentile distribution of shoal material in the major shoal areas was computed for both model and prototype, and this comparison is shown in Table 1.

7. In addition to measuring the channel quantities, the distribution of shoaling material from bank to bank in the four major shoal areas was recorded photographically at the end of the test (see Photos 1 and 2). These photographs show the base sediment deposition patterns and were used to evaluate the deposition patterns recorded during subsequent disposal area tests. The agreement between corresponding model and prototype percentile distribution as shown in Table 1 was judged to

be satisfactory, and the model was considered verified with respect to shoaling. It was also concluded that the crushed and graded gilsonite, mixed with water and injected into the model, would be transported and deposited by model currents in similar fashion to the actual dispersion and deposition of a major portion of the material dredged from the channels during the maintenance process and subsequently discharged in the disposal areas.

Disposal Area Tests

8. All tests were conducted for mean conditions of tide, salinity, and freshwater inflow described in paragraph 3. The model was operated for a minimum of 26 tidal cycles to obtain a stable salinity regimen, prior to starting the disposal area tests. The gilsonite-water mixture was adjusted in a tank to obtain 10 percent gilsonite and 90 percent water by volume and subsequently dumped at surface depth into the disposal area in the model to simulate prototype pipeline disposal operations. The quantity of gilsonite dumped into each disposal area was based on: (a) the annual prototype shoaling rate for the adjacent shoal reach as shown in Tables 1 and 2, and (b) a sufficient quantity of gilsonite to ensure satisfactory detection by photography. The total quantity of gilsonite needed for satisfactory evaluation of the Tribell shoal area was determined by trial and error, then the quantity used for tests of other shoal areas was determined by the percentage relationships of the respective annual prototype shoaling rates to the Tribell shoal rate as shown in Table 1. The rate of dumping in each area was determined by the daily prototype dredge-advancement rates for the individual areas as shown in Table 2.

9. In order to accurately introduce shoal material into the model in a simulative fashion that could be repeated exactly from test to test, the following procedures were developed. Small diameter rods were set along the center lines of the disposal areas at distances equal to one-half the length dredged per day as shown in Table 2. One-half of the total amount of material required to simulate one day's dredging in

the shoal being tested was divided into 25 equal parts and these amounts were injected half hourly for one complete tidal cycle at each pin location in turn. After completing the dredging simulation, model operation was continued for an additional 25 tidal cycles to permit the tidal currents ample time to disperse the dredged material. Upon completion of the tests the model tide generator was stopped, the model water was pooled at about the elevation of high water, and 8- by 10-in. vertical photographs were made to show the dispersion limits of the shoal material. These photographs were used to construct large mosaics of the area being tested and were subsequently compared with similar mosaics made during model shoaling verification. The two large mosaics (disposal areas versus verification) were compared to identify zones of heavy, medium, and light deposition of the dredged material released in the disposal areas. The surface areas of each zone of deposition classification were determined, and estimates of the maximum depth loss per year in the disposal areas were made. It is pointed out that these comparisons and computations are quite qualitative in nature and were made with reservation only because an estimate of the useful life of the present disposal procedure was urgently needed. The amounts of material placed in the disposal areas in these tests were considerably more than the amounts deposited in respective channel reaches during the shoaling verification tests. This was necessary to provide sufficient material to satisfactorily define deposition patterns of the material injected in the disposal areas. In the shoaling verification tests, insufficient material was available to accurately define deposition patterns at significant distances from the navigation channel.

Tribell shoal reach

10. The Tribell shoal reach of the navigation channel is that portion of the James River between river miles 28 and 33 generally north of Hog Island as shown in Figure 2 and Photo 3. The reach is divided into two portions by a short reach of the channel that essentially does not shoal. The downstream portion, shoal A, extends from about river mile 28.0 to about river mile 29.8, while shoal B extends between river miles 31.2 and 33.0. Three material distribution tests were made for

Tribell shoal reach: one for shoal A in which only the dredging of the downstream portion was simulated with dumping in the existing disposal area on the north side of the channel; one for shoal B in which only the dredging of the upstream portion of the shoal was simulated with dumping in the existing disposal area on the north side of the channel; and the third (plan 1) which involved the substitution of a 4000-ft-long disposal area to the south of the channel for an equal length at the downstream end of the existing disposal area used for dredging in shoal A.

11. Photo 3 shows the results of tests conducted in the model to determine the effectiveness of the existing disposal areas A and B located adjacent to Tribell shoals A and B and about 1600 ft north of and parallel to the channel alignment. The results indicate that most of the material dumped in the existing disposal area remains in the disposal area and does not return to the navigation channel. A portion of the dredged material placed in the downstream 4000 ft of disposal area A moved directly downstream and deposited in considerable quantity in about 2500 ft of the Skiffes Creek navigation channel. Experiments were conducted to locate an alternate area from which material would not rapidly fill the Skiffes Creek channel or return to the main river navigation channel. An equal 4000-ft-long area on the opposite side of the James River navigation channel was selected for formal testing; and the results, also shown in Photo 3, indicate that material dumped in the revised location of the 4000-ft section would either remain in the relocated disposal area or be dispersed into nonmaintained areas and not return to the navigation channel. A major portion of the material dumped in the remainder of the existing disposal area on the northern side of the channel remains in the disposal area and does not return to the James River navigation channel or to the Skiffes Creek access channel.

12. In order to get some idea of the relationships of the deposition patterns observed in these tests to the day-by-day deposition patterns that normally occur in the estuary, the photographs for the existing disposal area tests shown in Photo 3 were compared with the verification test photographs shown at the top of Photo 1. The comparison indicated that the deposition caused by the dredging and dumping

procedure is insignificant with respect to shoaling in the maintained channel as compared with the natural long-term deposition in the area.

13. In order to get some idea of how long the existing disposal areas A and B will perform efficiently, the surface areas covered by light, medium, and heavy deposition (Photo 3) were determined. The areas covered by each of the divisions were determined to be: light deposition, 4,500,000 sq yd; medium deposition, 2,800,000 sq yd; and heavy deposition, 2,000,000 sq yd. Assuming that about 60 percent of the annual maintenance dredging of 82,000 cu yd is deposited in the zone of heavy deposition, that portion of the disposal area is filled at a rate of approximately 0.07 ft/yr with a lesser rate of fill in the zones of light and medium deposition. The useful life of the disposal area would depend upon establishment of the minimum allowable depths over the area determined to meet ecological and hydraulic requirements. It should be noted, however, that at this rate about 14 yr would be required to reduce the water depth by 1.0 ft. Sufficient prototype data could not be found to confirm this filling rate. Additional tests should be conducted in the model to determine the effects of the disposal areas filled to capacity on tides, currents, salinities, shoaling, and dispersion patterns. For example, the area indicated to be optimum on the basis of the above test results could be completely filled to some assumed condition that would exist in the future after many years of continued use. The disposal tests could be repeated for the assumed future condition to determine if changes in hydraulic or other conditions, as a result of complete or partial filling, would alter various environmental factors.

Goose Hill shoal reach

14. Channel shoaling in Goose Hill reach occurs in three sections: C, a one-mile section between river miles 34.2 and 35.2; D, a 1.8-mile-long shoal extending from mile 35.2 to 37.0; and E, an 0.8-mile-long section extending from river mile 37.5 to 38.3. A single test was first made for the existing disposal areas which were all 1600 ft south of and parallel to the channel. The results of this test (see top photograph in Photos 4 and 5), which simulated dredging about 160,000 cu yd in

20 days, indicated that considerable dredged material returned to the channel; therefore, various alternate areas were tested in attempts to locate more efficient disposal areas.

15. The first alternate tested involved relocation of the disposal area for shoal C to 1600 ft north of and parallel to the channel. The existing disposal areas for shoals D and E were not changed, and this arrangement is referred to as plan 1 in the bottom photograph in Photo 4, which also shows the results of the disposal test for existing conditions for comparison. Material deposition in the channel was reduced but not to the extent desired.

16. The second alternate tested, referred to as plan 2 in Photo 5, consisted of relocation of the disposal areas for shoals D and E to 1600 ft north of and parallel to the channel. Again dredging the entire reach was simulated. The results of this test are shown in the bottom photograph in Photo 5, and the results of the test of the existing disposal areas are shown in the top photograph for comparative purposes. Considerable material returned to the navigation channel, and it was difficult to determine which of the three disposal areas was the major contributor.

17. Plan 3 consisted of relocating disposal area C and the downstream 3150 ft of disposal area D to 1600 ft north of and parallel to the channel. Dumping in disposal area E and the remainder of disposal area D was not simulated in this test. Dredging in the amount of 87,500 cu yd during 9 days was simulated. In order to evaluate the test, a similar test for the existing locations (south of the channel) for the corresponding portions of disposal areas C and D was made. The results of both tests are shown in Photo 6, with the results of the test for existing conditions being shown in the top photograph and the results of the plan 3 tests being shown in the bottom photograph. Considerable material returned to the navigation channel for existing conditions, whereas essentially no material returned to maintained areas with the disposal areas relocated to the north of the channel. Shifting the disposal areas for shoal C and the downstream 3150 ft of shoal D from the south side to the north side of the channel appears to be justified.

18. A test of existing area E and the remaining 6300 ft of disposal area D was then made and the results are shown in Photo 7. This test simulated disposal of 72,500 cu yd in 11 days. Practically all material deposited in or near these areas remains in the immediate vicinity and does not return to the navigation channel. Therefore, it is concluded that existing disposal area E and the upstream 6300 ft of disposal area D are satisfactory. The recommended dredged material areas for the Goose Hill shoal reach thus consist of the existing disposal areas in approximately the upstream half of the reach and disposal areas relocated to the opposite side of the channel in the downstream half of the reach.

19. In order to get some idea of the deposition patterns observed in the tests of the recommended disposal areas and the day-by-day deposition pattern that normally occurs in the estuary, Photos 6 and 7 were compared with the bottom photograph in Photo 1. The comparison indicated that the area affected by the natural long-term deposition is confined to 2000 to 3000 ft north and south of the navigation channel, whereas the deposition resulting from the dredging and dumping procedure is spread over areas located much farther from the navigation channel. Therefore, combining the day-by-day deposition patterns that normally occur with the deposition caused by the dredging and free-dumping procedure caused a much wider dispersal of the dredged material.

20. In order to get some idea of how long the revised disposal area would perform efficiently, the areas on both sides of the channel covered by the dispersed shoaling material were divided into zones of light, medium, and heavy deposits (Photos 6 and 7). For the north side (bottom photograph in Photo 6), the surface areas covered by each of the divisions were determined to be 3,700,000, 3,200,000, and 2,000,000 sq yd, respectively. Assuming that about 60 percent of the annual maintenance dredging of 87,500 cu yd (about half of the total annual maintenance dredging in the Goose Hill shoal reach) was deposited in the zone of heavy deposit, that zone would be filled at a rate of approximately 0.08 ft/yr with a lesser rate of fill in the zones of light and medium deposit. The area covered by the shoal material dumped

in the disposal area south of the channel was also divided into zones of light, medium, and heavy deposit (Photo 7). The surface areas covered by each of the divisions were determined to be 12,700,000, 6,500,000, and 2,400,000 sq yd, respectively. Assuming that about 60 percent of the annual maintenance dredging of 72,500 cu yd (the remaining portion of the total annual maintenance dredging in the Goose Hill shoal reach) was deposited in the zone of heavy deposit, that zone would be filled at a rate of approximately 0.05 ft/yr with a lesser rate of fill in the zones of light and medium deposit. At these rates, 13 to 20 yr would be required to reduce the depth by 1.0 ft. Further tests similar to those recommended for the Tribell shoal reach should also be conducted for the Goose Hill shoal reach to determine effects of partially filling the deposition areas.

Dancing Point-Swann Point shoal reach

21. Shoals F, G, and H are located in the Dancing Point-Swann Point reach of James River. Shoal F is about 1.0 mile long, extending from river mile 41.3 to 42.3. Shoal G, located between miles 46.5 and 47.5, is also about 1.0 mile long. Shoal H is about 0.8 mile long and extends from mile 47.7 to 48.5. The existing disposal areas are all located to the south of the navigation channel and as elsewhere are of equal length to the respective shoal sections. The model test simulated an 18-day dredging effort to move about 331,000 cu yd as shown in Table 2.

22. The results of the test as shown in Photo 8 indicate that most of the material dumped in the existing disposal area remains in the vicinity of the disposal area and does not return to the channel in significant amounts, except on the south side of the channel at shoal H. This return to the channel was relatively minor; therefore, it was not considered necessary to test alternate disposal area locations for this reach.

23. In order to compare the deposition patterns observed in this test with the day-by-day deposition patterns that normally occur in the estuary, Photo 8 was compared with the top photograph in Photo 2. The comparison indicated that the deposition caused by the dredging and

dumping procedure is insignificant as compared with the natural long-term deposition in the area.

24. In order to estimate how long the area will perform efficiently, the portion on the south side of the channel covered by the dispersed shoaling material was divided into zones of light, medium, and heavy deposition (Photo 8). The surface areas covered by each of the three classifications were determined to be 12,000,000, 5,300,000, and 7,300,000 sq yd, respectively. Assuming that about 60 percent of the annual maintenance dredging of 331,000 cu yd is deposited in the zone of heavy deposition, that zone is filled at a rate of approximately 0.08 ft/yr with a lesser rate of fill in the zones of light and medium deposit. At this rate, about 13 yr would be required to reduce the depth by 1.0 ft. Further tests, similar to the tests recommended for the Tribell shoal reach, could also be conducted for the Dancing Point-Swann Point shoal reach after determination of minimum allowable depths in the disposal area.

Jordan Point-
<u>Windmill Point shoal reach</u>

25. Shoaling in the Jordan Point-Windmill Point reach occurs in three sections, J, K, and L, located between river miles 65.3 and 65.7, 66.2 and 67.1, and 67.4 and 69.0, which are about 0.4, 0.9, and 1.6 miles long, respectively. The existing disposal areas used for the three shoals are all located 1600 ft north of and parallel to the navigation channel and separate tests were first made for each area. For shoal J (disposal area 1), the dredging volume simulated was about 46,000 cu yd during a 3-day period. In the test for shoal K (disposal area 2), the volume and time were about 77,000 cu yd and 5 days; and for the test for shoal L (disposal area 3), about 56,000 cu yd and 8 days were simulated. Tests of alternate disposal areas for shoals J and K were made when the fill rate in disposal areas 1 to 3 were determined to be somewhat higher than found previously.

26. Photo 9 shows the results of tests using existing disposal areas 1, 2, and 3 located adjacent to shoal areas J, K, and L, respectively, in the Coggins Point-Windmill Point portion of the overall reach.

The results indicate that most of the material dumped in the various disposal areas either remains in the areas or is dispersed into nonmaintained areas and does not return to the navigation channel. Although the top photograph in Photo 9 indicates that the zone of moderate deposition from disposal area 1 crosses the navigation channel at river mile 65, close examination of the full-size photographs showed that very little material actually deposited in the channel. The test results also show that disposal area 2 (just downstream from Herring Creek), which would be used during dredging operations in shoal K, is probably undesirable because of the indicated large movement of material into Herring Creek (see center photograph in Photo 9).

27. In order to evaluate the deposition patterns observed in these tests with the day-by-day deposition pattern that normally occurs in the estuary, the photograph in Photo 9 was compared with the bottom photograph in Photo 2. The comparison indicated that the deposition caused by the dredging and dumping procedure is insignificant as compared with the natural long-term deposition in the area.

28. In order to estimate how long the disposal areas will perform efficiently, the areas covered by the dispersed shoaling material were evaluated to identify zones of light, medium, and heavy deposition (Photo 9). The surface areas covered by each of the classifications for disposal area 1 (see top photograph in Photo 9) were determined to be 3,500,000, 1,900,000, and 400,000 sq yd, respectively. Assuming that about 60 percent of the annual maintenance dredging of 46,000 cu yd (about 26 percent of the total annual maintenance dredging of 179,000 cu yd in the Jordan Point-Windmill Point shoal) is deposited in the zone of heavy deposit, that zone is filled at a rate of approximately 0.20 ft/yr (about 5 yr/ft), with a lesser rate of fill in the zones of light and medium deposit. For disposal area 2 (see center photograph in Photo 9), the surface areas determined for each classification were 4,100,000, 2,200,000, and 850,000 sq yd, respectively. Assuming that about 60 percent of the annual maintenance dredging of 77,000 cu yd (about 43 percent of the total annual maintenance dredging of 179,000 cu yd in the Jordan Point-Windmill Point shoal) is deposited

in the zone of heavy deposition, that zone is filled at a rate of approximately 0.16 ft/yr (about 6 yr/ft) with a lesser rate of fill in the zones of light and medium deposit. The surface areas covered by each of the classifications for disposal area 3 (see bottom photograph in Photo 9) were determined to be 4,500,000, 1,700,000, and 1,200,000 sq yd, respectively. Assuming that about 60 percent of the annual maintenance dredging of 56,000 cu yd (about 31 percent of the total annual maintenance dredging of 179,000 cu yd in the Jordan Point-Windmill Point shoal) is deposited in the zone of heavy deposit, that zone is filled at a rate of approximately 0.08 ft/yr (about 13 yr/ft) with a lesser rate of fill in the areas of light and medium deposit.

29. Because of the relatively high filling rates (and thus limited effective lives) of existing disposal areas 1 and 2, several alternate locations (disposal areas 4, 5, 30, and 31) were tested. Photo 10 shows the results of tests using proposed disposal areas 4 and 5 for spoiling material from shoal areas J and K, respectively. In the top photograph of Photo 10, disposal area 4 is shown to be on the south side of the channel and along the north bank of Windmill Point, while the bottom photograph shows disposal area 5 to be about 1600 ft south of and parallel to the channel alignment in the vicinity of shoal K. For the test using disposal area 5, the high-water channel along the north side of Windmill Point was filled. The results indicated that most of the material dumped in spoil areas 4 and 5 would remain in the disposal areas or be dispersed into nonmaintained areas and not returned to the navigation channel.

30. In order to estimate how long the proposed disposal areas 4 and 5 would perform efficiently, the area covered by the dispersed shoaling material was divided into zones of light, medium, and heavy deposit (Photo 10). The surface areas covered by each of the divisions for disposal area 4 (see top photograph in Photo 10) were determined to be 1,045,000, 430,000, and 475,000 sq yd, respectively. Assuming that about 60 percent of the annual maintenance dredging of 46,000 cu yd (about 26 percent of the total annual maintenance dredging of 179,000 cu yd in the Jordan Point-Windmill Point shoal) was deposited

in the zone of heavy deposit, that zone would be filled at a rate of approximately 0.17 ft/yr (about 6 yr/ft) with a lesser rate of fill in the zones of light and medium deposition. The surface areas covered by each of the divisions for disposal area 5 (see bottom photograph in Photo 10) were determined to be 910,000, 1,450,000, and 400,000 sq yd, respectively. Assuming that about 60 percent of the annual maintenance dredging of 77,000 cu yd (about 43 percent of the total annual maintenance dredging of 179,000 cu yd in the Jordan Point-Windmill Point shoal) was deposited in the zone of heavy deposit, that zone would be filled at a rate of approximately 0.35 ft/yr (about 3 yr/ft) with a lesser rate of fill in the zones of light and medium deposit.

31. The results of the test of disposal area 3 indicate that the annual fill rate of the area was comparatively high, and therefore, alternate disposal areas could possibly be utilized if such satisfactory areas could be located. Areas 30 and 31 (best shown in Photo 10) located in the embayment south of the navigation channel and upstream of Coggins Point were tested. The dredging of shoal L, 56,000 cu yd in about 9 days, was simulated for both tests.

32. Photo 11 shows the results of tests to determine the effectiveness of existing disposal areas 30 and 31. The results indicate that most of the material dumped in these disposal areas would remain in the general areas and only a small percentage would return to the navigation channel. Also, a small percentage would move into the secondary channel separating the two disposal areas.

33. In order to get some idea of how long disposal areas 30 and 31 would perform efficiently, the areas covered by the dispersed shoaling material were divided into zones of light, medium, and heavy deposit (Photo 11). The surface areas covered by each of the divisions for disposal area 30 (see left photograph in Photo 11) were determined to be 8,500,000, 4,200,000, and 2,600,000 sq yd, respectively. Assuming that about 60 percent of the annual maintenance dredging of 56,000 cu yd (the total annual maintenance dredging in shoal L) was deposited in the zone of heavy deposition, that zone would be filled at a rate of approximately 0.04 ft/yr (about 25 yr/ft) with a lesser rate of fill in the

zones of light and medium deposit. The surface areas covered by each of the divisions for disposal area 31 (see right photograph in Photo 11) were determined to be 3,100,000, 1,500,000, and 2,600,000 sq yd, respectively. Assuming that about 60 percent of the annual maintenance dredging of 56,000 cu yd (the total annual maintenance dredging in shoal L) was deposited in the zone of heavy deposit, that zone would be filled at a rate of approximately 0.10 ft/yr (about 10 yr/ft) with a lesser rate of fill in the zones of light and medium deposition.

Herring Creek Sediment Trap Tests

34. Test results of existing open-water disposal methods in the Jordan Point-Windmill Point reach indicated that considerable material discharged in area 2 could be carried into Herring Creek. The maximum annual estimated filling rate in disposal areas 1 to 5 was comparatively high, varying between about 0.08 and 0.35 ft and indicating a minimal life expectancy for the present method and areas. An alternate method was proposed that involved dredging a sediment trap in the inside of the bend in the navigation channel opposite the mouth of Herring Creek. Material depositing in the trap could be removed by hopper dredge or other means and placed in disposal areas from which it would not return to the system. This process should reduce deposition in Herring Creek and extend the life of the disposal areas.

35. The model was revised to include the sediment trap, as shown by the crosshatched area in Figure 3, dredged to depths of both -35 and -25 ft mlw. Shoaling tests using the same techniques established during the verification procedure and outlined in paragraphs 3-7 were repeated in turn for base test conditions and for both trap depths. The shoal material was retrieved from the navigation channel between miles 61 and 76, and the volumes measured are shown in Table 3. The shoal material was retrieved by sections selected to show effects of the trap on channel shoaling in a 5-mile reach (mile 61 to 65) downstream from the immediate vicinity of the trap; in the four 1-mile-long sections closest to the trap; and in a 7-mile reach upstream from the trap. In Table 3, in

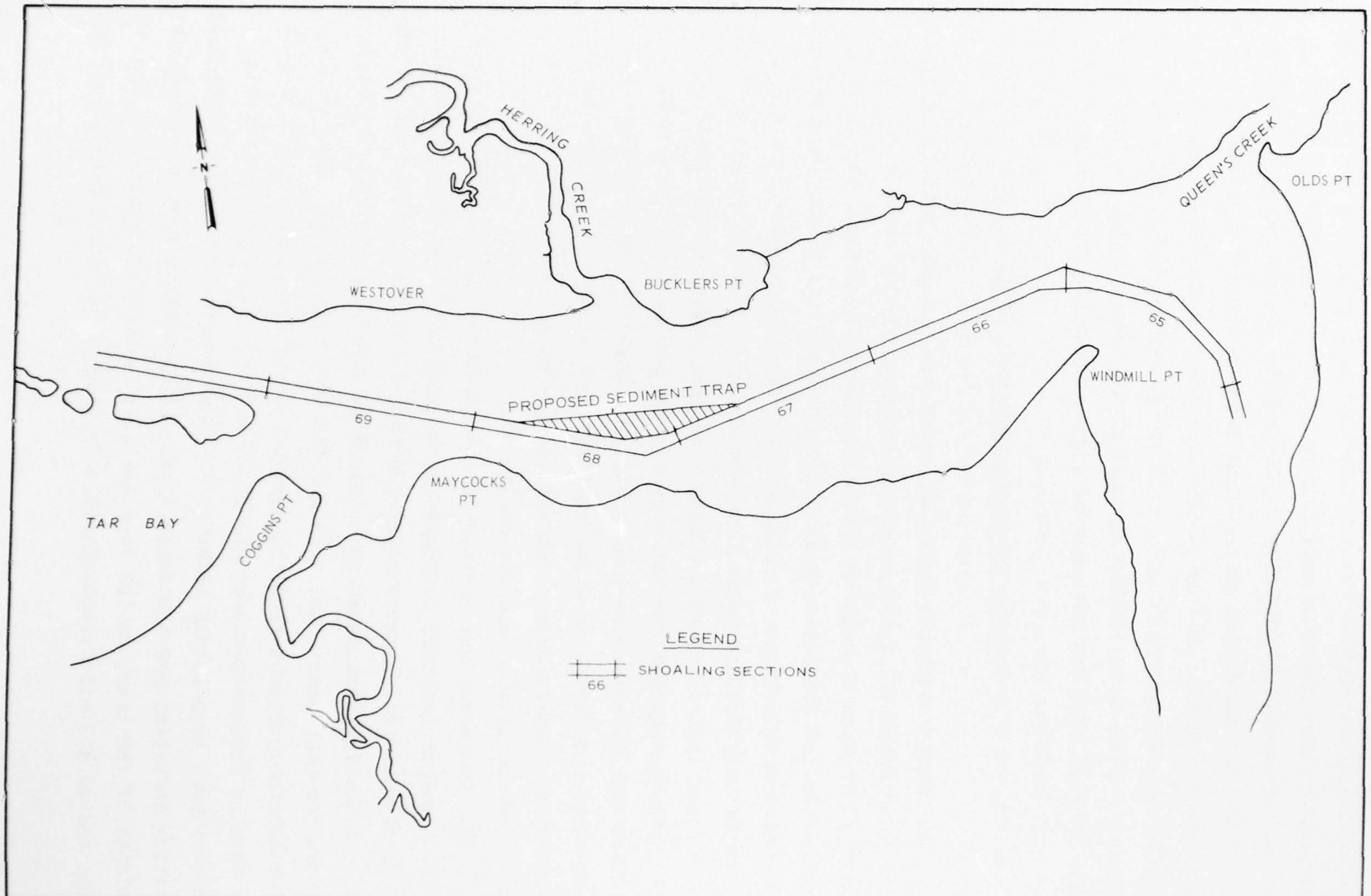


Figure 3. Herring Creek sediment trap

addition to volumes of material dredged from each section for the three conditions tested, the effects of the changes from existing to proposed conditions are shown as indices, the volume for proposed conditions divided by the volume for existing conditions to give the percent change.

36. With the sediment trap dredged to -25 ft mlw, slightly more material deposited in the 5-mile reach downstream of the trap, indicating possibly that enlargement of the cross section by construction of the trap would increase the net downstream transport in the reach. Shoaling in the four adjacent sections was reduced by the trap by a total amount almost equal to the deposition in the trap. Deposition in the 7-mile upstream section was reduced slightly more than the increase in deposition downstream. The most significant effect of deepening the trap to -35 ft mlw was the increase (almost 30 percent) in deposition in the trap.

37. Assuming that about 50 percent, or 80,000 cu yd, of the shoaling in the Jordan Point-Windmill Point shoal reach deposits in the sections adjacent to the proposed trap, the 25-ft-deep trap would reduce the annual channel shoaling by 16 percent or by about 12,800 cu yd, and the 35-ft-deep trap would reduce channel shoaling by 21 percent or about 16,800 cu yd. The remainder of the annual shoaling in this channel reach would still have to be dredged and placed in disposal areas. Construction of the 25-ft-deep trap would require dredging about 540,000 cu yd, and deepening the trap to 35 ft would require removal of an additional 1,410,000 cu yd, including deepening the adjacent channel area. The economic feasibility of constructing the trap will depend on the proximity of a long-term disposal area for initial construction and periodic restoration of the trap, the effects of the trap on the frequency of dredging operations, the relative cost of dredging from the trap as compared with dredging from the channel, and other factors. For the reasons stated, WES is not in a position to comment on economic feasibility; however, it appears that a trap would not be justifiable and that the small additional benefits of a 35-ft-deep trap, as compared with the large amount of additional dredging required to obtain that

depth, would not in any event justify construction of a trap to a depth greater than 25 ft.

PART III: CONCLUSIONS

38. The results of the tests summarized herein support the following conclusions:

- a. The downstream 4000 ft of the existing dredged material disposal area for the Tribell shoal reach should be moved from the north side to the south side of the channel to eliminate material movement from this section into the Skiffes Creek channel just downstream of the disposal area.
- b. The remainder of the existing Tribell shoal disposal area is an effective disposal area and material dumped therein does not return to the channel or other maintained areas in any significant quantity.
- c. The estimated loss of depth in the Tribell shoal disposal areas is less than 0.10 ft/yr, indicating that the areas can be utilized at the present rate for many years to come without adversely affecting the hydraulic or dispersion characteristics of the reach.
- d. A significant amount of the material placed in the downstream 8450 ft of the existing disposal areas in the Goose Hill shoal reach returns to the navigation channel.
- e. Shifting the downstream 9000 ft of the existing Goose Hill shoal reach disposal area from the south side to the north side of the channel would probably be beneficial. Material dumped in the revised location would either remain in the relocated disposal area or be dispersed into nonmaintained areas and not return to the navigation channel.
- f. Material dumped in the remainder of the existing Goose Hill shoal reach disposal area deposits in or near the disposal area and does not return to the navigation channel.
- g. The estimated losses of depth in the Goose Hill disposal areas were also less than 0.10 ft/yr, indicating again that the areas can be used at the present rate for many years to come.
- h. Most of the material dumped in the existing Dancing Point-Swann Point shoal reach disposal areas remains in the vicinity of the disposal areas and does not return to the channel.
- i. The estimated annual loss of depth in the Dancing Point-Swann Point disposal areas was again less than 0.10 ft, indicating that the areas can be used at the present rate for many years.

j. Most of the material dumped in existing or proposed disposal areas located on either side of the channel in the Jordan Point-Windmill Point shoal reach remains in the areas and does not return to the navigation channel.

k. Disposal area 2 in the Jordan Point-Windmill Point shoal reach just downstream from Herring Creek, used when dredging shoal K, is probably undesirable because of the indicated large movement of material into Herring Creek.

l. The estimated annual losses of depth in the downstream five sections (disposal areas 1 to 5) of the Jordan Point-Windmill Point disposal areas varied between about 0.10 and 0.40 ft and indicate this reach to be the most critical with respect to continuing present channel maintenance practices. Plans for an alternate disposal scheme for this reach should be developed, and close surveillance of the disposal areas should be maintained.

m. Most of the dredged material discharged into disposal areas 30 and 31 in the Jordan Point-Windmill Point shoal reach would remain in the general area with an insignificant amount returning to the maintained channel. The estimated annual depth loss in both areas was about 0.04 ft.

n. Further tests should be conducted in the model to determine the effects of filling the disposal areas to minimum allowable depths and subsequently determine another estimate of the useful life of all disposal areas. For example, the disposal area could be completely filled to some assumed condition that would exist in the future because of continued use. The disposal tests could be repeated for the future filled condition to determine associated changes in hydraulic, salinity, shoaling, and dispersion conditions. Estimates of environmental impact could then be made.

o. The annual shoaling rate in the Jordan Point-Windmill Point reach of the channel does not appear large enough to justify extensive advance maintenance. Sediment traps are better suited to rapidly shoaling reaches that cannot be maintained within the normal dredging cycle. The results of the sediment trap tests indicated that the interval between required dredging in this reach would not be increased; however, the amount of material removed annually from the channel would be reduced somewhat until the trap is filled. The large amount of material that would have to be removed during the construction of the sediment trap may create a more severe disposal problem than presently exists with routine maintenance.

Table 1

Shoaling Verification

Shoaling Section	Annual Prototype Shoaling cu yd	Annual Prototype Shoaling Percent	Model Shoaling cc	Model Shoaling Percent	Difference, Percent
Tribell Mile 29-33	82,000	11	3,650	18	+7
Goose Hill Mile 35-38	160,000	21	4,315	21	0
Dancing Point-Swann Point Mile 43-49	331,000	44	7,290	36	-8
Jordan Point-Windmill Point Mile 64-72	179,000	24	5,075	25	+1
Total	752,000	100	20,330	100	

Table 2

Prototype Shoaling Statistics

Shoal Reach	Approximate Limits, River Miles	Approximate Length of Shoal* ft	Annual Volume Dredged cu yd	Time Required to Dredge days	Length Dredged per Day ft	Volume Dredged per Day cu yd
Tribell	28-33	19,000	82,000	22	870	3,727
Goose Hill	34-38	18,950	160,000	20	930	8,000
Dancing Point-Swann Point	42-49	15,000	331,000	18	840	18,389
Jordan Point-Windmill Point	63-72	13,900	179,000	16	850	11,188
		Total	752,000			

* This column shows the length of the reach that is subjected to shoaling.

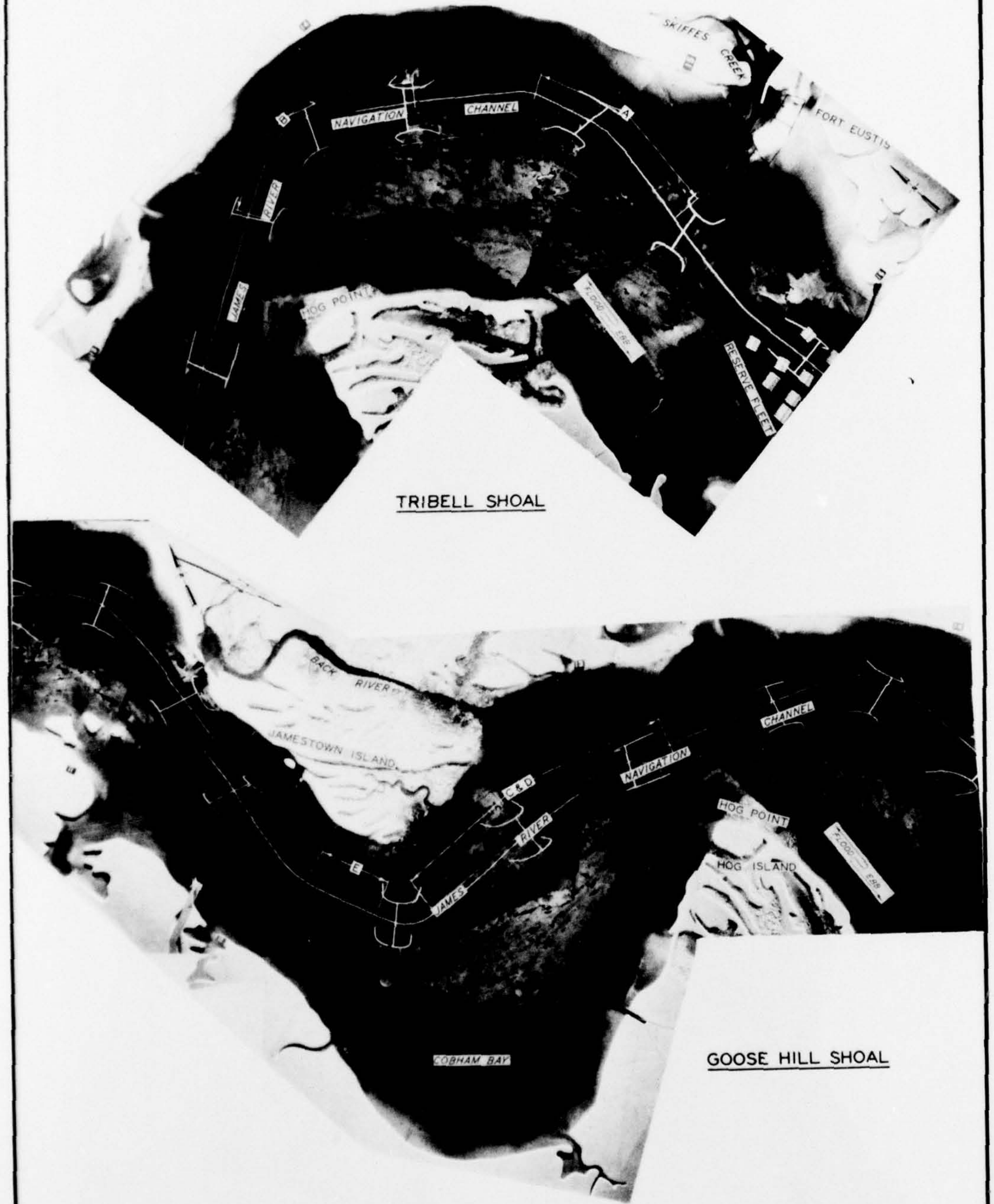
Table 3

Effects of Herring Creek Sediment Trap on Shoaling

One-Mile Channel Sections	Base Volume cc	Trap Dredged to -25 ft mlw Volume cc	Trap Dredged to -25 ft mlw Index*	Trap Dredged to -35 ft mlw Volume cc	Trap Dredged to -35 ft mlw Index*
Downstream					
61-65	1750	1935	1.11	1660	0.95
Adjacent					
66	630	560	0.89	610	0.97
67	880	660	0.75	540	0.61
68	940	740	0.79	610	0.65
69	1310	1190	0.91	1220	0.93
Subtotal	3760	3150	0.84	2980	0.79
Proposed Trap	0	680		890	
Upstream					
70-76	3395	2920	0.86	3175	0.94
Total	8905	8685	0.98	8705	0.98

Note: Limits of trap are shown in Figure 3.

* Index equals plan volume divided by base test volume.

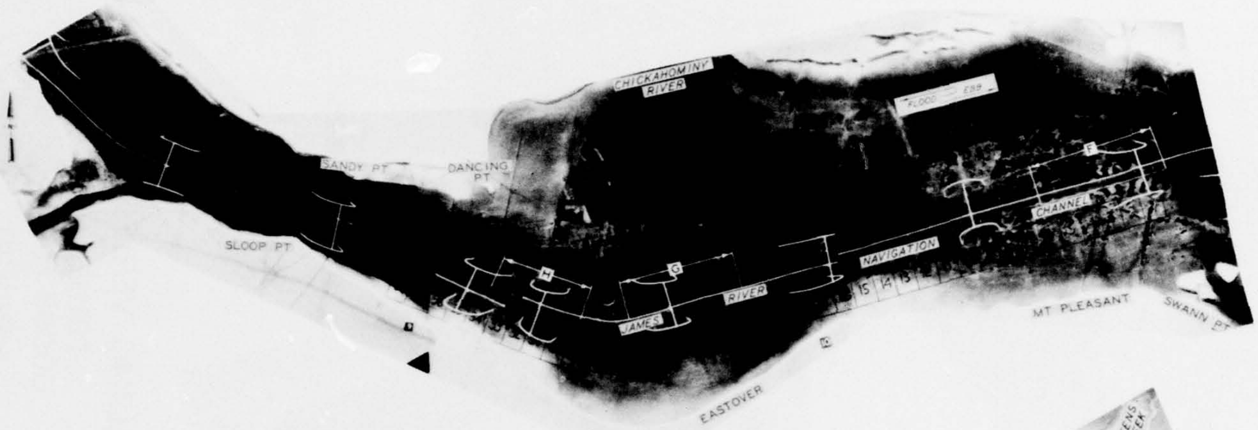


SHOALING VERIFICATION
TRIBELL
GOOSE HILL

SCALES IN FEET

PROTOTYPE 5000 0 5000 10,000

MODEL 5 0 5 10



DANCING PT - SWANN PT SHOAL

JORDAN PT - WINDMILL PT SHOAL

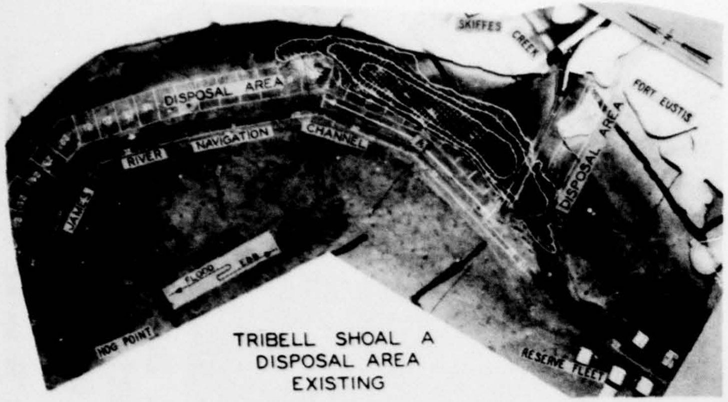
SHOALING VERIFICATION

DANCING PT - SWANN PT
JORDAN PT - WINDMILL PT

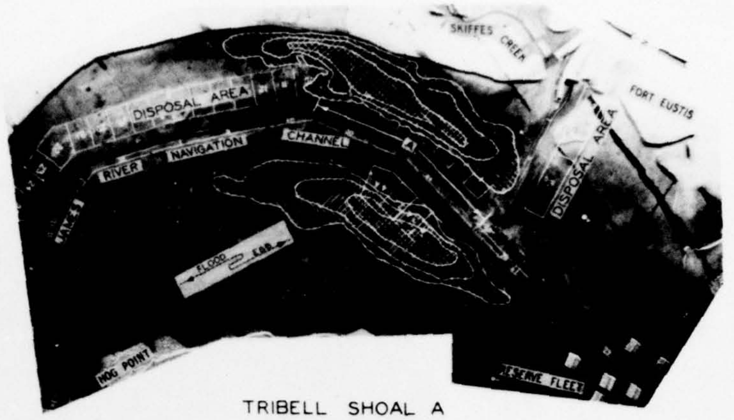
SCALES IN FEET

PROTOTYPE 5000 0 5000 10,000
MODEL 5 0 5 10

PHOTO 2

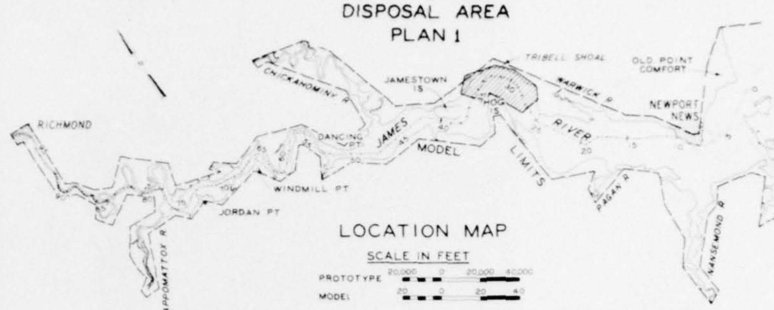


TRIBELL SHOAL A
DISPOSAL AREA
EXISTING



TRIBELL SHOAL A
DISPOSAL AREA
PLAN 1

TRIBELL SHOAL B
DISPOSAL AREA
EXISTING



LOCATION MAP

SCALE IN FEET

PROTOTYPE 20,000 0 20,000 40,000
MODEL 20 0 20 40

LEGEND
LIGHT DEPOSIT
MEDIUM DEPOSIT
HEAVY DEPOSIT

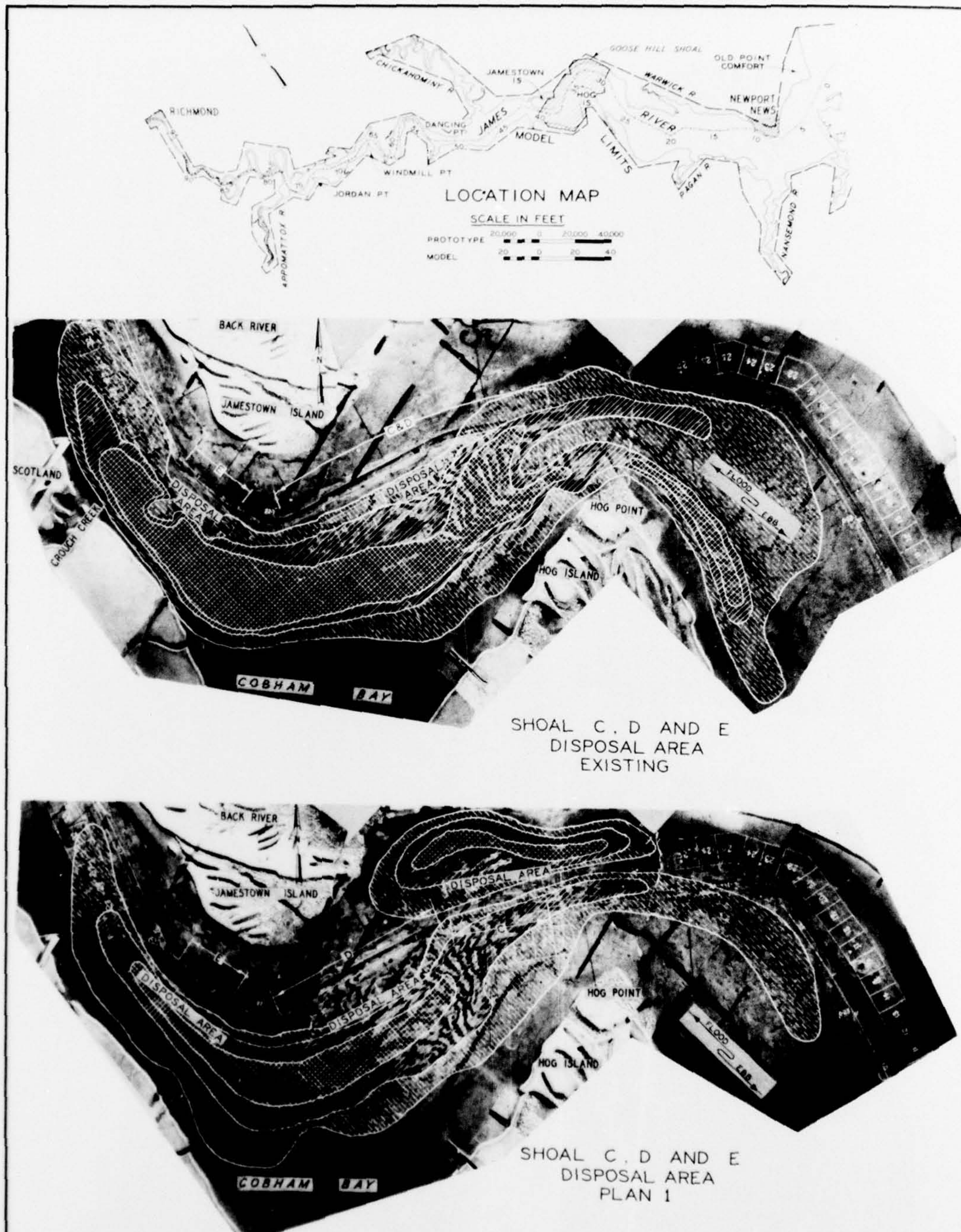
TRIBELL SHOAL

SPOIL DISPOSAL STUDIES
EXISTING AND PLAN 1
DISPOSAL AREAS

SCALE IN FEET

PROTOTYPE 5000 0 5000 10,000
MODEL 5 0 5 10

PHOTO 3



GOOSE HILL SHOAL

SPOIL DISPOSAL STUDIES
EXISTING AND PLAN I
DISPOSAL AREAS

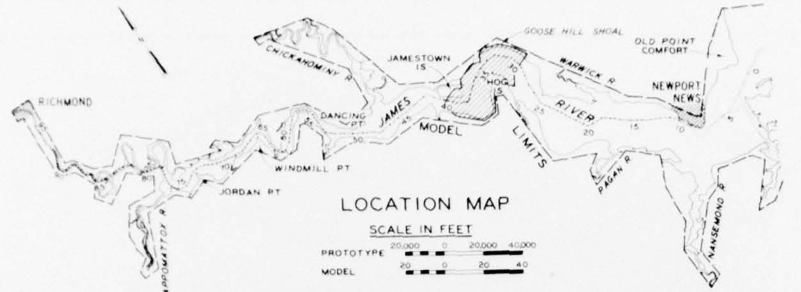
LEGEND
- LIGHT DEPOSIT
- MEDIUM DEPOSIT
- HEAVY DEPOSIT

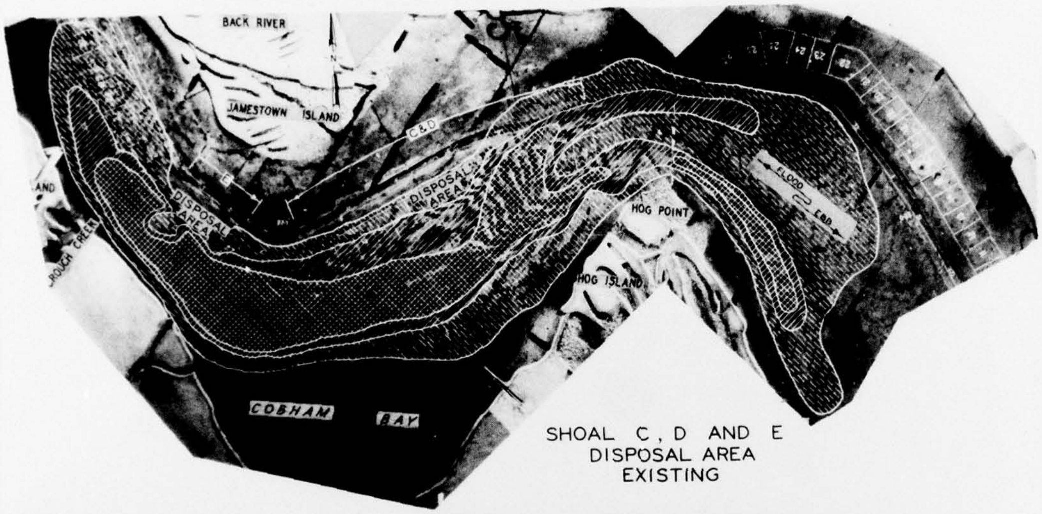
SCALE IN FEET

PROTOTYPE 5000 0 5000 10,000

MODEL 5 0 5 10

PHOTO 4





SHOAL C, D AND E
DISPOSAL AREA
EXISTING

SHOAL C, D AND E
DISPOSAL AREA
PLAN 2

GOOSE HILL SHOAL

SPOIL DISPOSAL STUDIES

EXISTING AND PLAN 2 DISPOSAL AREAS

LEGEND
- LIGHT DEPOSIT
- MEDIUM DEPOSIT
- HEAVY DEPOSIT

SCALE IN FEET
PROTOTYPE 5000 0 5000 10000
MODEL 5 0 5 10

PHOTO 5

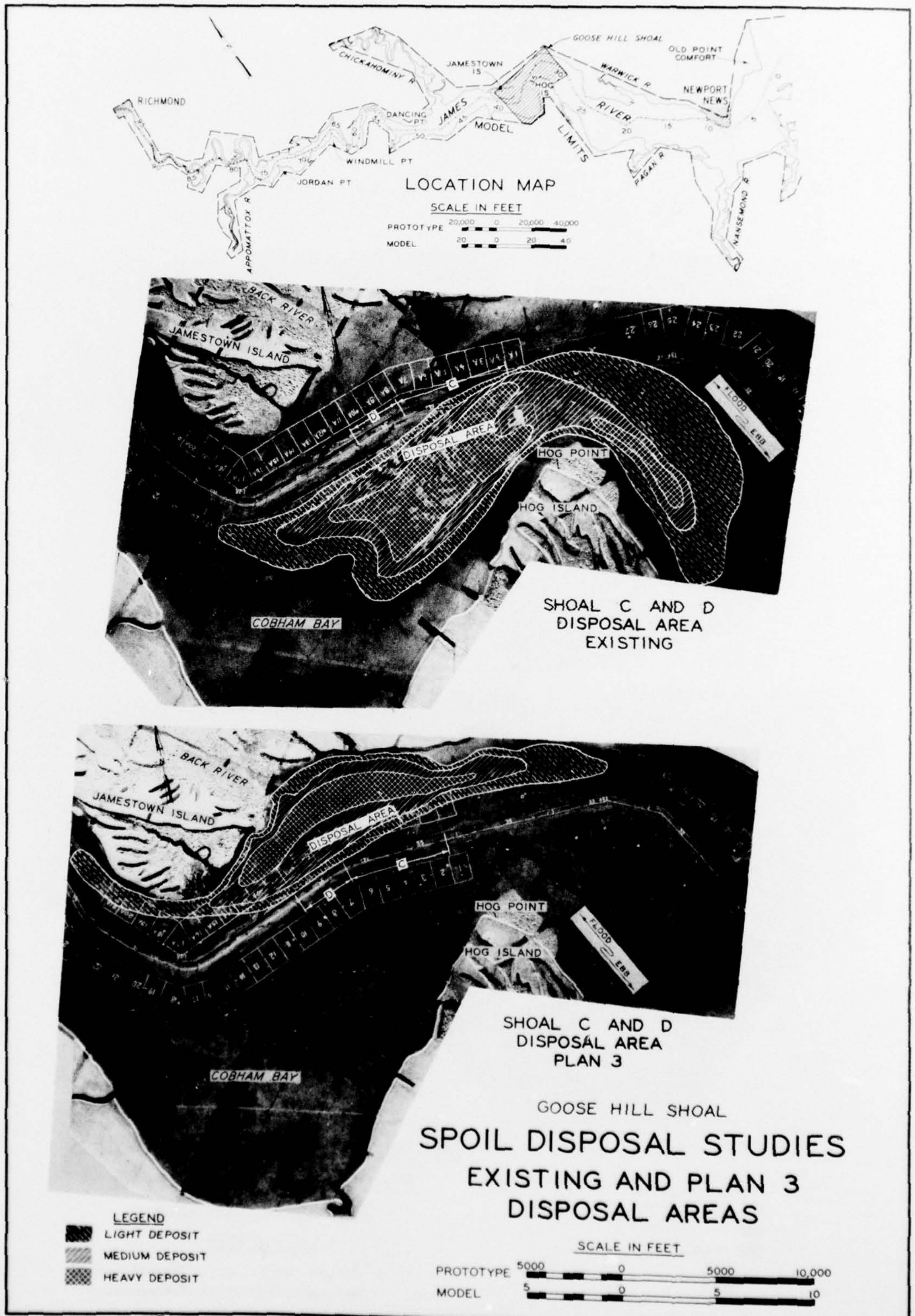
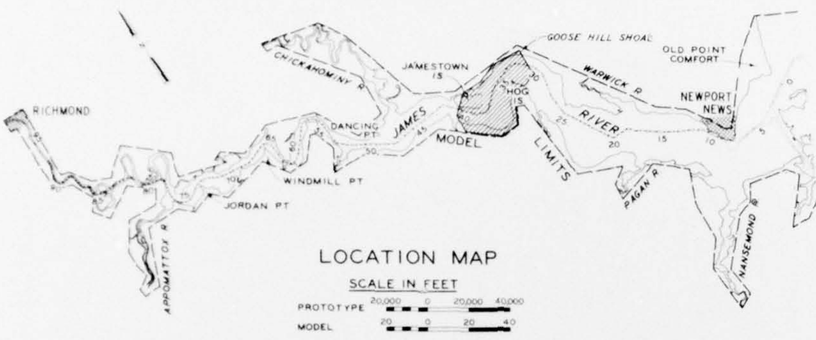
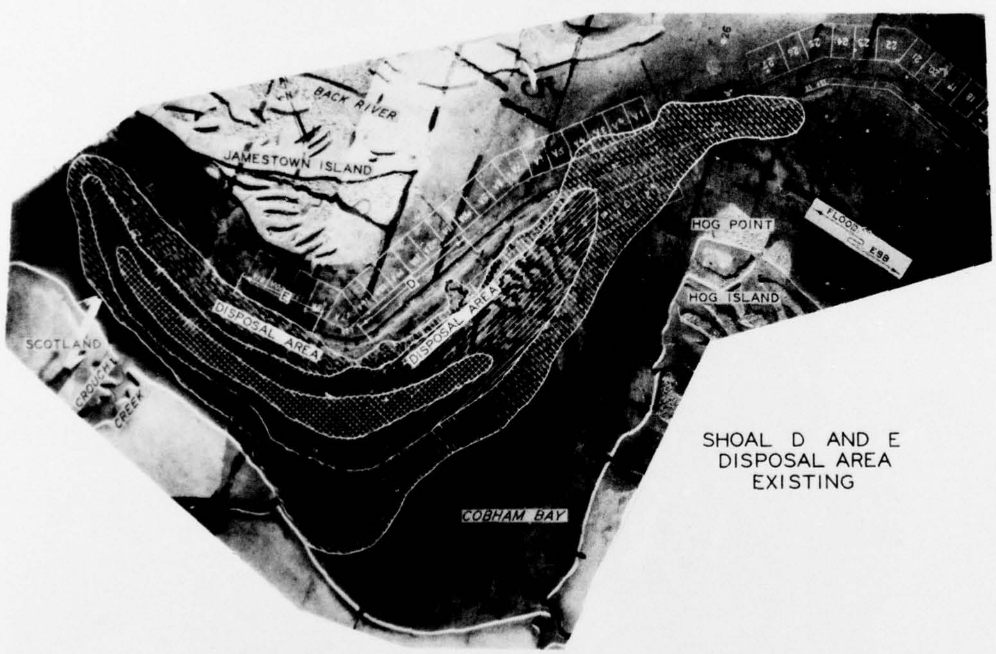

GOOSE HILL SHOAL
OLD POINT COMFORT
JAMESTOWN
CHICKAHOMINY R
HOG I
WARWICK R
RICHMOND
NEWPORT NEWS
JAMES
RIVER
DANCING PT
MODEL
LIMITS
WINDMILL PT
JORDAN PT
PAGAN R
LOCATION MAP
SCALE IN FEET
PROTOTYPE 20,000 0 20,000 40,000
MODEL 20 0 20 40
APPOMATTOX R
NANSEMOND R
BACK RIVER
JAMESTOWN ISLAND
DISPOSAL AREA
HOG POINT
HOG ISLAND
FLOOD
EBB
COBHAM BAY
SHOAL C AND D
DISPOSAL AREA
EXISTING
BACK RIVER
JAMESTOWN ISLAND
DISPOSAL AREA
HOG POINT
HOG ISLAND
FLOOD
EBB
COBHAM BAY
SHOAL C AND D
DISPOSAL AREA
PLAN 3
GOOSE HILL SHOAL
SPOIL DISPOSAL STUDIES
EXISTING AND PLAN 3
DISPOSAL AREAS
LEGEND
LIGHT DEPOSIT
MEDIUM DEPOSIT
HEAVY DEPOSIT
SCALE IN FEET
PROTOTYPE 5000 0 5000 10,000
MODEL 5 0 5 10

PHOTO 6





SHOAL D AND E
DISPOSAL AREA
EXISTING

LEGEND

- LIGHT DEPOSIT
- MEDIUM DEPOSIT
- HEAVY DEPOSIT

GOOSE HILL SHOAL

SPOIL DISPOSAL STUDIES
EXISTING DISPOSAL AREAS

SCALE IN FEET

PROTOTYPE 5000 0 5000 10,000

MODEL 5 0 5 10

PHOTO 7

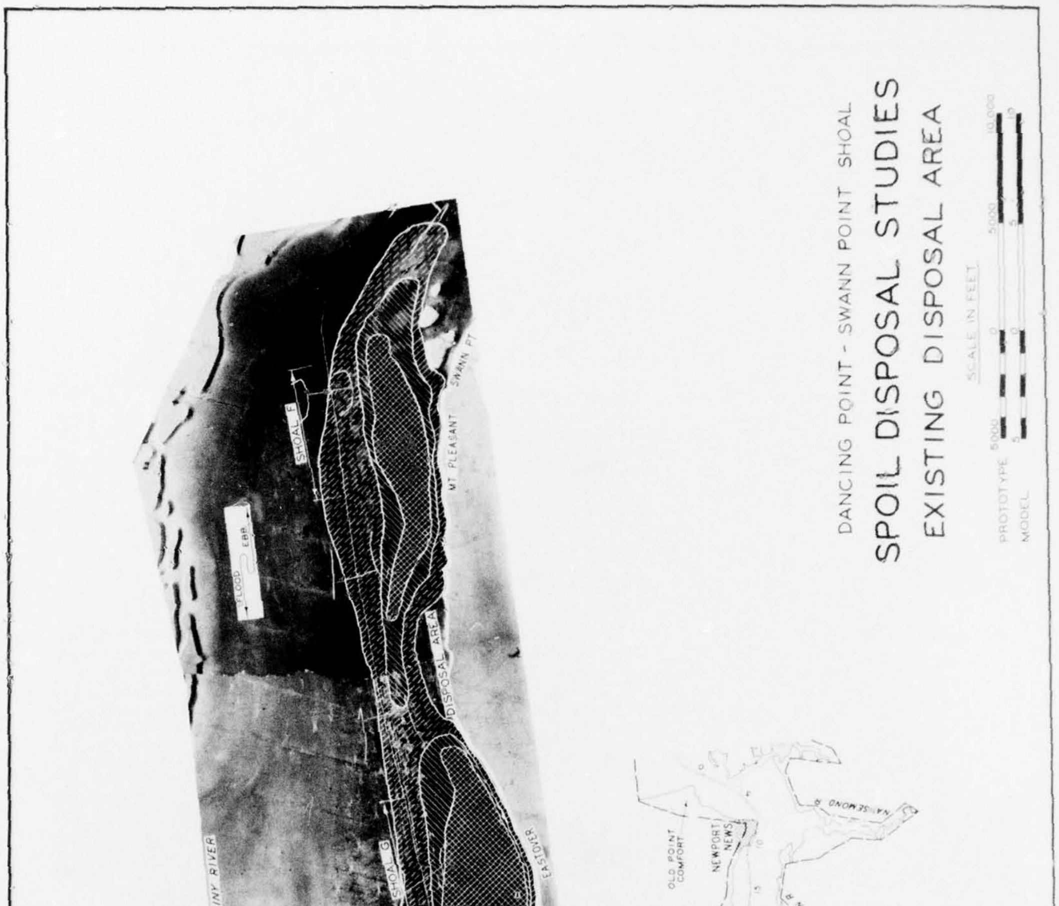
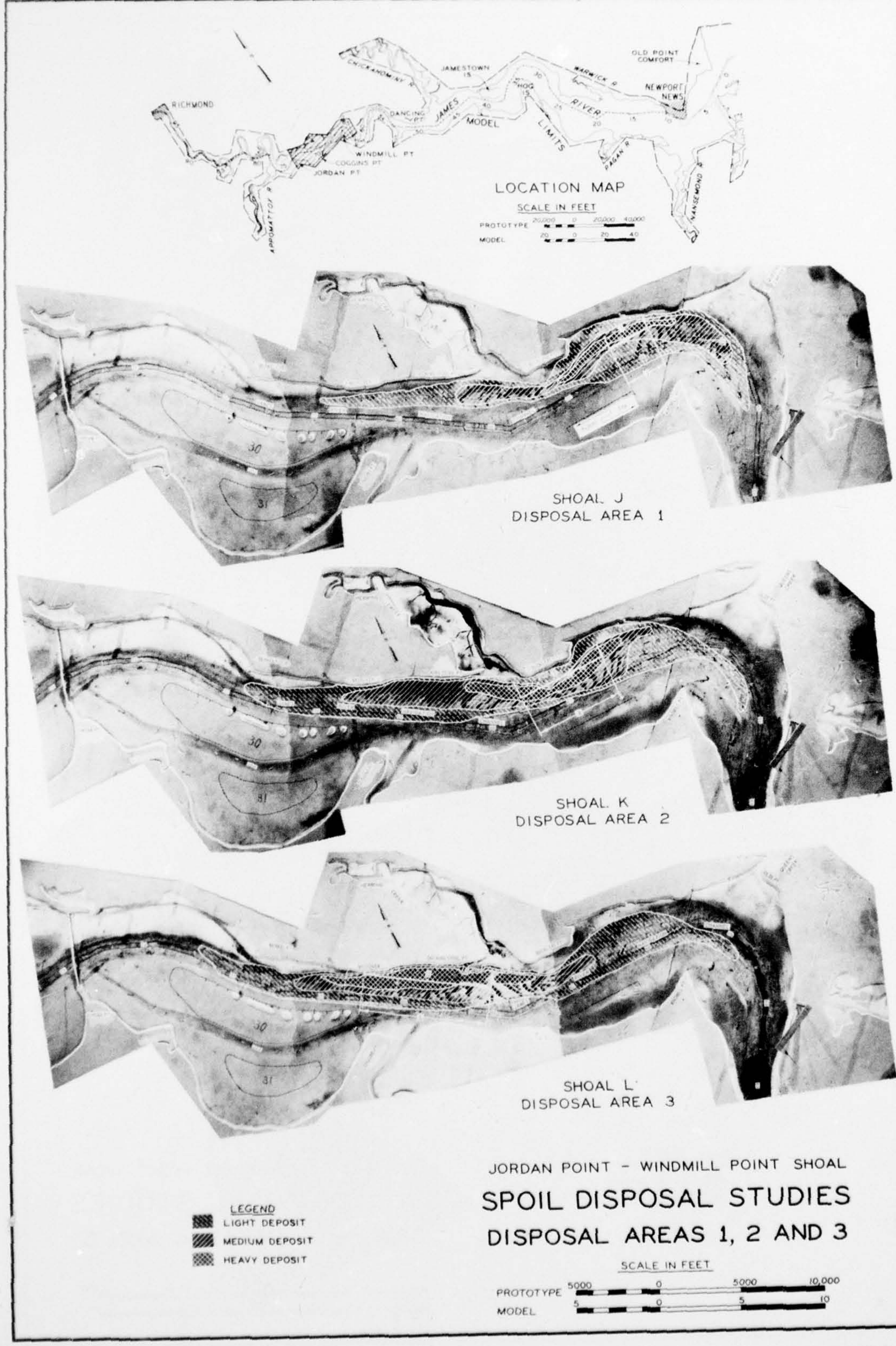

DANCING POINT - SWANN POINT SHOAL
SPOIL DISPOSAL STUDIES
EXISTING DISPOSAL AREA
SCALE IN FEET
PROTOTYPE 5000 0 5000 10000
MODEL 5 0 5 10
LEGEND
LIGHT DEPOSIT
MEDIUM DEPOSIT
HEAVY DEPOSIT
CHICKAHOMINY RIVER
JAMES RIVER NAVIGATION CHANNEL
SHOAL F
SHOAL G
SHOAL H
DISPOSAL AREA
DISPOSAL AREA
FLOOD
EBB
SANDY PT
DANCING PT
SLOOP PT
EASTOVER
MT PLEASANT
SWANN PT
LOCATION MAP
SCALE IN FEET
RICHMOND
APPOMATTOX R
JORDAN PT
WINDMILL PT
CHICKAHOMINY R
JAMESTOWN IS
DANCING PT SWANN PT SHOAL
MODEL LIMITS
JAMES RIVER
WARWICK R
OLD POINT COMFORT
NEWPORT NEWS
PAGAN R
NANSEMOND R

PHOTO 8



JORDAN POINT – WINDMILL POINT SHOAL

SPOIL DISPOSAL STUDIES

DISPOSAL AREAS 1, 2 AND 3

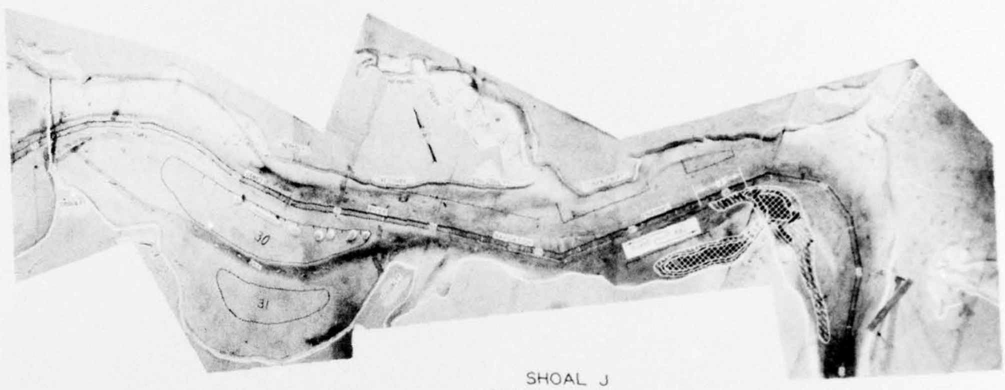
PHOTO 9

LOCATION MAP

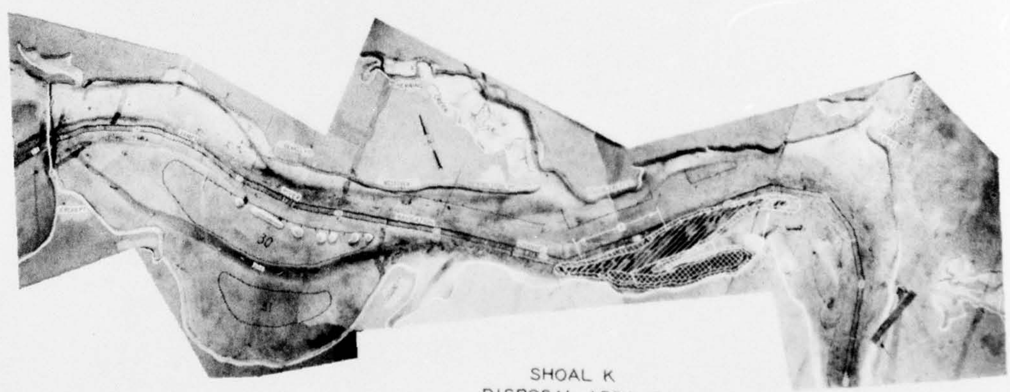
SCALE IN FEET

PROTOTYPE 20,000 0 20,000 40,000

MODEL 20 0 20 40



SHOAL J
DISPOSAL AREA 4



SHOAL K
DISPOSAL AREA 5

LEGEND

- LIGHT DEPOSIT
- MEDIUM DEPOSIT
- HEAVY DEPOSIT

JORDAN POINT – WINDMILL POINT SHOAL

SPOIL DISPOSAL STUDIES

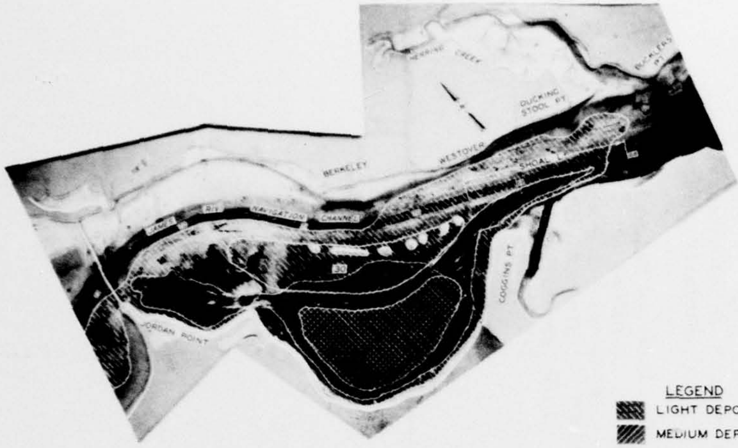
DISPOSAL AREAS 4 AND 5

SCALE IN FEET

PROTOTYPE 5000 0 5000 10,000

MODEL 5 0 5 10

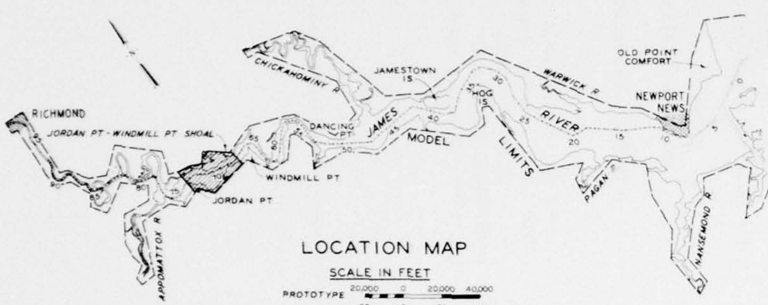
PHOTO 10



SHOAL L
DISPOSAL AREA "30"

SHOAL L
DISPOSAL AREA "31"

LEGEND
- LIGHT DEPOSIT
- MEDIUM DEPOSIT
- HEAVY DEPOSIT



LOCATION MAP

SCALE IN FEET

PROTOTYPE 20,000 0 20,000 40,000
MODEL 20 0 20 40

JORDAN POINT - WINDMILL POINT SHOAL

SPOIL DISPOSAL STUDIES

DISPOSAL AREAS 30 AND 31

SCALE IN FEET

PROTOTYPE 5000 0 5000 10,000
MODEL 5 0 5 10

PHOTO 11

In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

Boland, Robert A

Evaluation of disposal areas in James River; hydraulic model investigation, by Robert A. Boland, Jr. [and] William H. Bobb. Vicksburg, U. S. Army Engineer Waterways Experiment Station, 1975.

1 v. (various pagings) illus. 27 cm. (U. S. Waterways Experiment Station. Miscellaneous paper H-75-1)

Prepared for U. S. Army Engineer District, Norfolk, Norfolk, Virginia.

1. Dredged material. 2. Hydraulic models. 3. James River. 4. Sediment. 5. Waste disposal sites. I. Bobb, William H., joint author. II. U. S. Army Engineer District, Norfolk. (Series: U. S. Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper H-75-1)

TA7.W34m no.H-75-1